LQCD-ext
2014 Annual Review

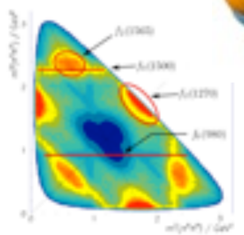
Response to Questions

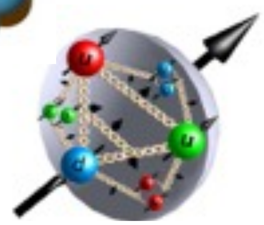
The USQCD Collaboration

http://www.usqcd.org

LQCD-ext 2014 Annual Review
Fermilab
May 15-16, 2014

1) What scientific milestones/goals are there? What have you achieved already? What are your goals now?





Relevant NSAC Milestones and their Status as of 2008/2009

Table 4: Milestone Progress in Hadronic Physics

(as of 2008)

Year	Milestone	Complete?	Status Assessment
2009 HP3	Complete the combined analysis of available data on single π, η, and K photo-production of nucleon resonances and incorporate the analysis of two-pion final states into the coupled-channel analysis of resonances.	No	Expect to Not Achieve Fully
2014 HP9	Perform lattice calculations in full QCD of nucleon form factors, low moments of nucleon structure functions and low moments of generalized parton distributions including flavor and spin dependence.	No	Expect to Exceed
2014 HP10	Carry out ab initio microscopic studies of the structure and dynamics of light nuclei based on two-nucleon and many-nucleon forces and lattice QCD calculations of hadron interaction mechanisms relevant to the origin of the nucleon-nucleon interaction.	No	Expect to Achieve

Spectrum

Structure
[met this year]

Interactions
[not achieved, but on track to accomplish]

2018	HP15 (new)	The first results on the search for exotic mesons using photon beams will be completed.
2020	FI15 (new)	Obtain initial results from an experiment to extend the limit on the electric dipole moment of the neutron by two orders of magnitude

Spectrum

Fundamental Symmetries

energy.gov/~/media/np/nsac/pdf/docs/perfmeasevalfinal.pdf

USQCD scientific goals & milestones

- USQCD regularly establishes and updates milestones through white papers
- 2007 white paper *Fundamental parameters from future lattice calculations* highlighted "three matrix elements which play a key role in constraining the SM", with a goal of obtaining "unquenched calculations … having all errors are controlled":
  - Neutral kaon mixing parameter B_K, neutral B_s-meson mixing matrix element f_{Bs} Sqrt[B_{Bs}], and the SU(3)-breaking ratio $\xi = f_{Bs}$ Sqrt[B_{Bs}]/f_{Bd} Sqrt[B_{Bd}]
  - Achieved continuum limit results for f_{Bs} Sqrt[B_{Bs}] & ξ in [HPQCD, PRD80 (2009) 014503], and for B_K in [Aubin, Laiho, RV PRD81 (2010) 014507]
- 2013 white paper *Lattice QCD at the Intensity Frontier* highlights calculations of the **$\Delta I=1/2$ rule and $\varepsilon'_K/\varepsilon_K$**, and of the **hadronic contributions to g-2** as critical for interpreting past and forthcoming experiments as tests of the Standard Model
  - Anticipate a complete calculation of $\varepsilon'_K/\varepsilon_K$ within 2 years and of the HVP contribution to g-2 within 5 years
  - Calculations of HLbL contribution to g-2 are in too early a stage for predictions

USQCD precision goals

- LQCD-ext proposal written in 2007-2008 included the following table showing the "present status and future prospects for lattice calculations which directly determine elements of the CKM matrix"

Quantity	CKM element	present expt. error	present lattice error	*predicted* 2009 lattice error	*actual* lattice error 2011	2012	2013
f_K/f_π	V_{us}	0.3%	0.9%	0.5%	0.6%	0.6%	0.4%
$f_{K\pi}(0)$	V_{us}	0.4%	0.5%	0.3%	0.5%	0.5%	0.4%
$D \to \pi\ell\nu$	V_{cd}	3%	11%	6%	10.5%	4.4%	4.4%
$D \to K\ell\nu$	V_{cs}	1%	11%	5%	2.5%	2.5%	2.5%
$B \to D^*\ell\nu$	V_{cb}	1.8%	2.4%	1.6%	1.8%	1.8%	1.8%
$B \to \pi\ell\nu$	V_{ub}	3.2%	14%	10%	8.7%	8.7%	8.7%

- Last three columns show the actual errors in these same quantities from 2011-2013
- Improvements in precision from both increased computing resources (*enabling lighter pions and finer lattice spacings*) and new methods

➡ For the most part **we are meeting our uncertainty goals**

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$D \to K\ell\nu$	V_{cs}	1%	11%	5%	2.5%	new method	
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f_K/f_π	V_{us}	0.3%	0.9%	0.5%	0.6%	continuum limit	
$f_{K\pi}(0)$	V_{us}	0.4%	0.5%	0.3%	0.5%	0.5%	0.4%
$D \to \pi\ell\nu$	V_{cd}	3%	11%	6%	10.5%	4.4%	4.4%
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Scientific goals in QCD Thermodynamics:

aligned with heavy ion research program as outlined in the 2007 NSAC plan

– important long-standing goals achieved in the last years:

i) calculation of the QCD transition temperature
ii) calculation of the equation of state at vanishing baryon number density

– further goals as outlined in the 2013 USQCD White Paper:

i) calculation of the phase boundary at non-zero baryon chemical potential (relation between QCD transition and freeze-out);
ii) calculation of higher order cumulants of conserved charge fluctuations (search for evidence for the existence of a critical point)
iii) EoS at non-zero baryon chemical potential muB< 2T, i.e. in the regime relevant for the beam energy scan at RHIC (input to hydrodynamic modeling of the expansion of dense matter)
iv) calculation of transport coefficients and heavy quark diffusion constants (establish the strongly interacting nature of the QGP)
v) perform detailed calculation of the heavy quark spectrum in the QGP (explore screening in the QGP)

2) How does the US effort compare with efforts in Asia and Europe.

A) In hardware (from LQCD-ext II proposal):

Country	Sustained teraflop/s
Germany	390
Japan	260
United Kingdom	260
Unites States	
LQCD Project	195
DOE Leadership Class Centers	170
US Total	365

TABLE X: Major computing resources in sustained teraflop/s estimated to be available for the study of lattice QCD in various countries, as of March, 2013.

B) Size of communities:

From the fact that 202 Europeans attended the Sardinia Lattice conference, 133 Americans attend the California lattice conference, and 112 people from outside those regions attended the Adelaide lattice conference, we would infer that there are over 466 lattice theorists throughout the world of whom around 30% are Americans, 45% are Europeans, and 24% are other.

International competition

- USQCD is leading the world in calculations of SM parameters and matrix elements
  - Single most precise calculation for all of the quantities in this table entry are by USQCD (except the last, where we are still closely competitive)

[Snowmass Quark-flavor WG report, 1311.1076]

Quantity	CKM element	Present expt. error	2007 forecast lattice error	Present lattice error	2018 lattice error
f_K/f_π	$\lvert V_{us}\rvert$	0.2%	0.5%	0.4%	0.15%
$f_+^{K\pi}(0)$	$\lvert V_{us}\rvert$	0.2%	–	0.4%	0.2%
$D \to \pi\ell\nu$	$\lvert V_{cd}\rvert$	2.6%	–	4.4%	2%
$D \to K\ell\nu$	$\lvert V_{cs}\rvert$	1.1%	–	2.5%	1%
$B \to D^*\ell\nu$	$\lvert V_{cb}\rvert$	1.3%	–	1.8%	$< 1\%$
$B \to \pi\ell\nu$	$\lvert V_{ub}\rvert$	4.1%	–	8.7%	2%
f_B	$\lvert V_{ub}\rvert$	9%	–	2.5%	$< 1\%$
ξ	$\lvert V_{ts}/V_{td}\rvert$	0.4%	2-4%	4%	$< 1\%$
B_K	$\mathrm{Im}(V_{td}^2)$	0.5%	3.5–6%	1.3%	$< 1\%$

- Further, USQCD is responsible for the most precise lattice determinations of α_s, the only (2+1)-flavor calculations of m_c and m_b, several important theoretical developments for the HVP contribution to muon g-2, and the only effort on the HLbL calculation to g-2

Comparison of US BSM effort with Europe and Japan

The BSM groups of Europe and Japan together are roughly comparable in size to the USQCD BSM group. Julius Kuti gave the final plenary talk on BSM at *31st International Lattice Meeting*, Mainz, Germany Aug 3, 2013.

USQCD BSM group has more than 30 active members with approximately 125 spires entries over the last five years (including proceedings) with approximately 2400 citations

European BSM group has approximately 70 spires entries over the last five years (including proceedings) with approximately 1000+ citations

Japanese BSM group has approximately 40 spires entries over the last five years (including proceedings) with several hundred citations

QCD Thermodynamics Effort in the International Context

major groups worldwide: hotQCD/BNL-Bielefeld
Wuppertal-Budapest (Fodor et al., Europe)
Mumbai (Gavai, Gupta, India)
WHOT (Hatsuda, Kanaya, Ejiri, Japan)

main competitor: Wuppertal-Budapest –
– took lead in Tc and EoS calculation;
– try to catch up with the BNL-Bielefeld fluctuation program;
– picked up the BNL-Pisa approach to QCD in external fields (B)

hotQCD/BNL-Bielefeld: Tc, EoS, finite-density via Taylor expansion;
spectral functions, transport staggered fermions, DWF
Publication 2009-2014: 12 (~1400 cit); cited>100: EoS 416, 149
Tc 253, B>0 131
Budapest-Wuppertal (Z. Fodor et al.): Tc, EoS, finite-density (recently also via Taylor expansion); staggered fermions, overlap
Publication 2009-2014: 17 (~1600 cit); cited>100: EoS 375,
Tc 326, 311, B>0 129

QCD Thermodynamics Effort in the International Context con'td

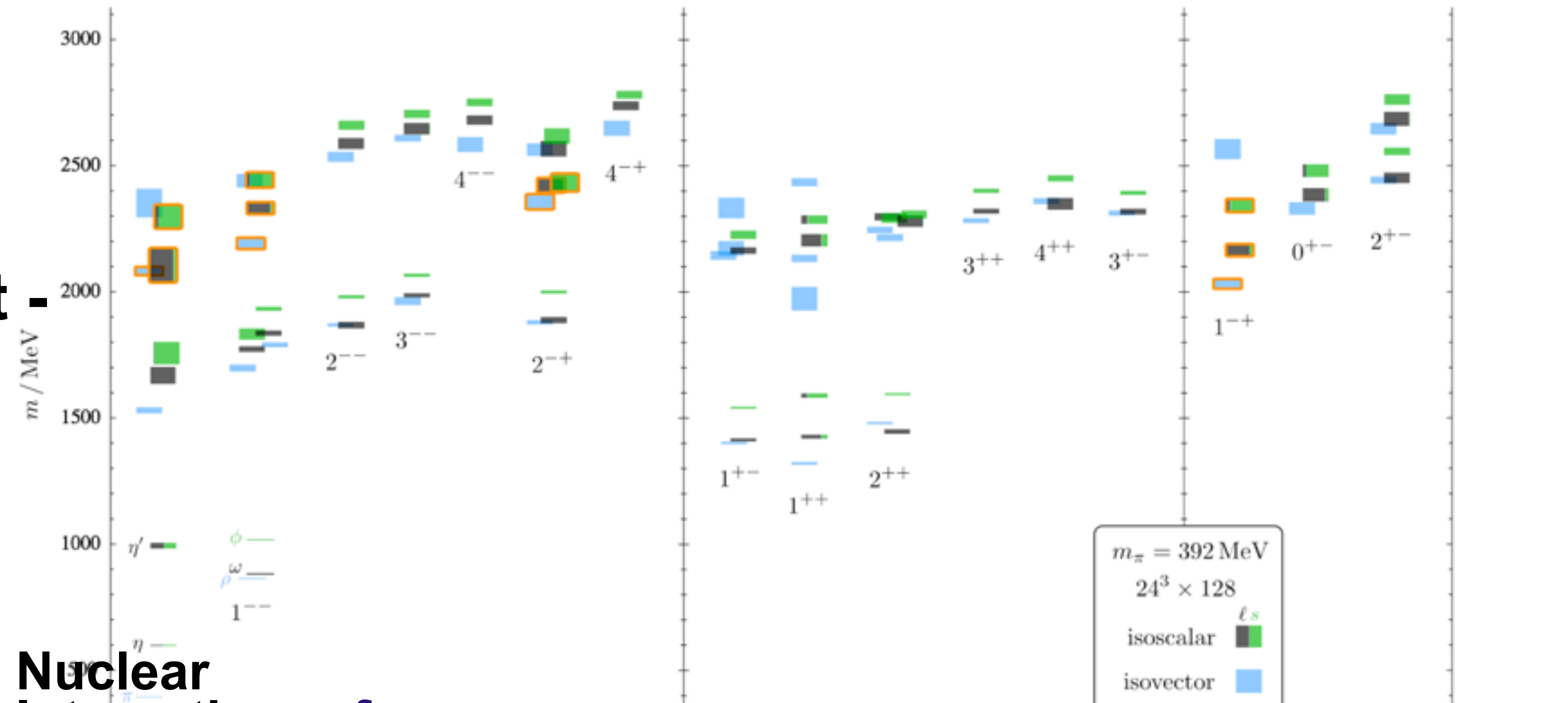
smaller efforts:
Mumbai (Gavai+Gupta): finite density QCD; staggered fermions

WHOT (T. Hatsuda, K. Kanaya, S. Ejiri et al): Tc, EoS, finite-density (Taylor expansion), spectral functions, Wilson fermions

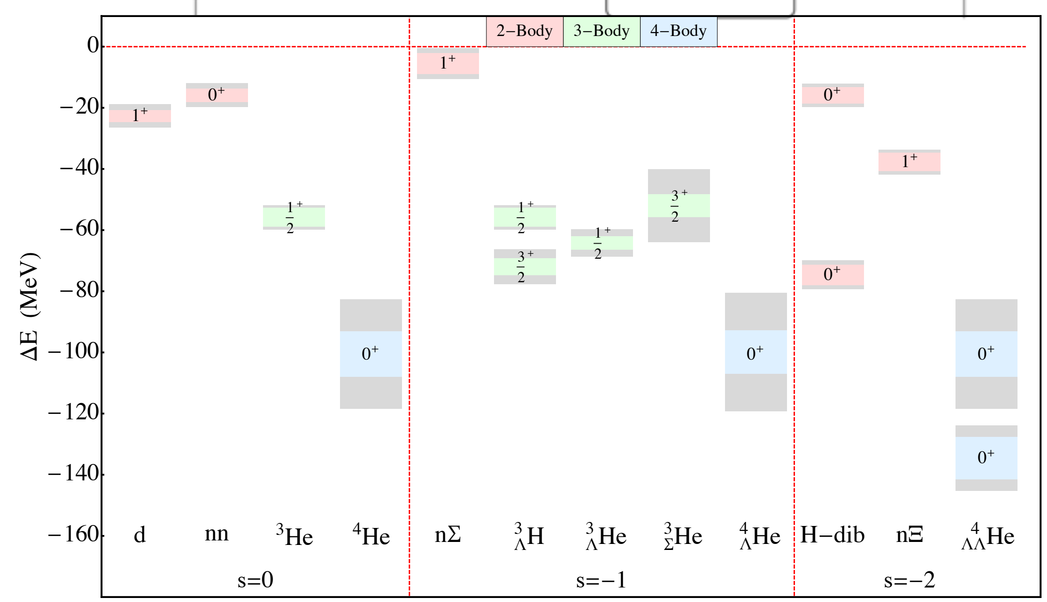
ColdQCD vs World

Spectroscopy - **USQCD dominant - integral to expt.**

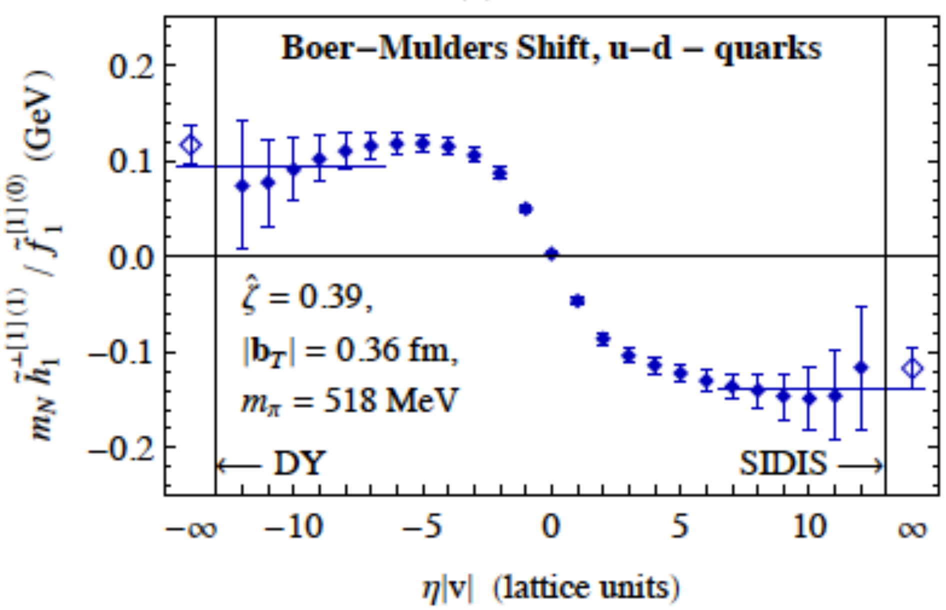
USQCD: 5 lattice plenaries since 2010



Nuclear Interactions; ***focus project in Japan***



High-precision calculations of hadron structure: ***Important competition, nota in Germany***



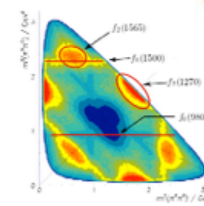
USQCD: 3 lattice plenaries since 2011

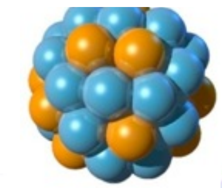
USQCD: 2 lattice plenaries since 2011

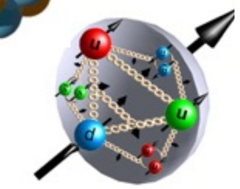
All projects integral to US NP Program, and key components of future program

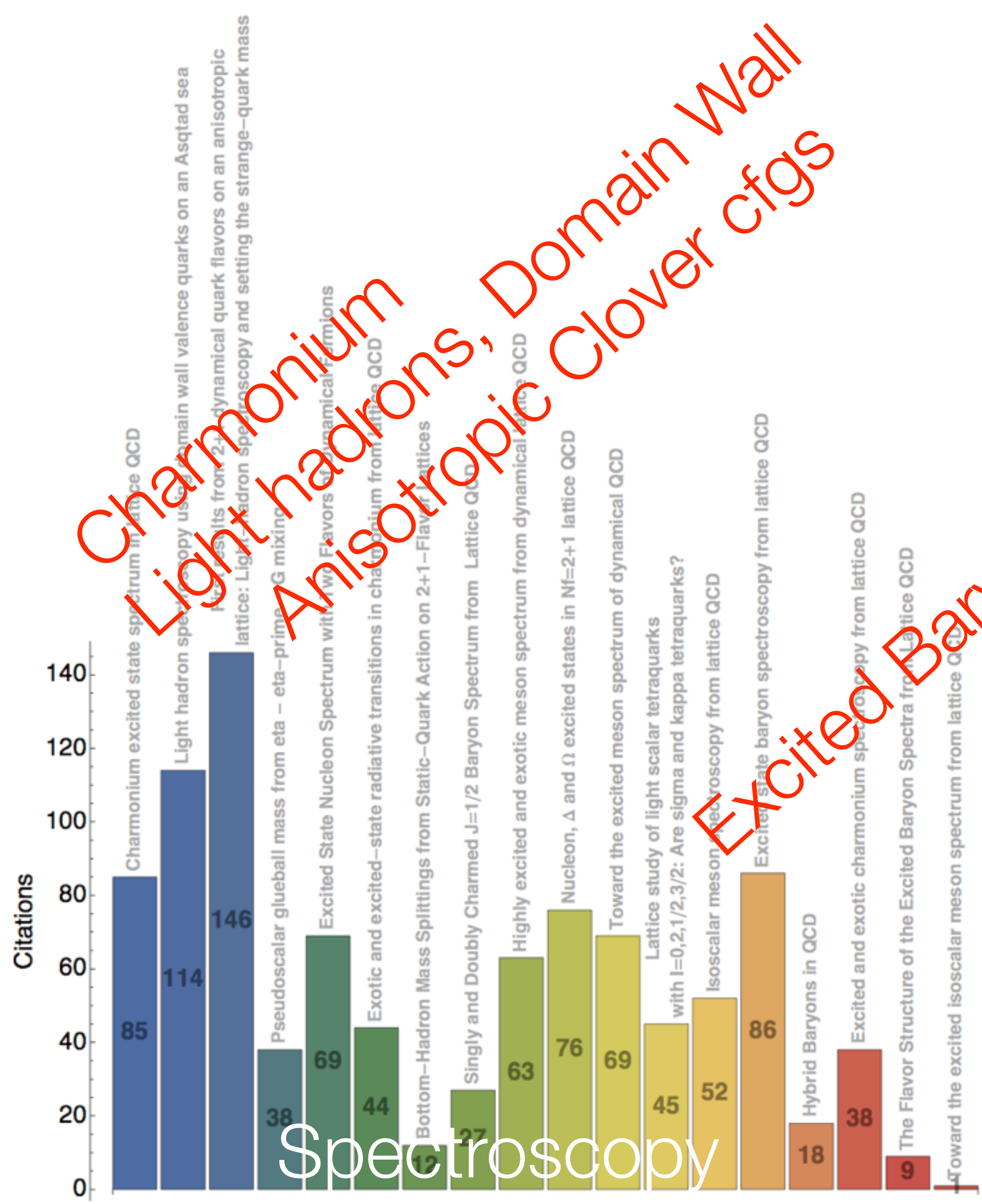
Impact 2007-2013

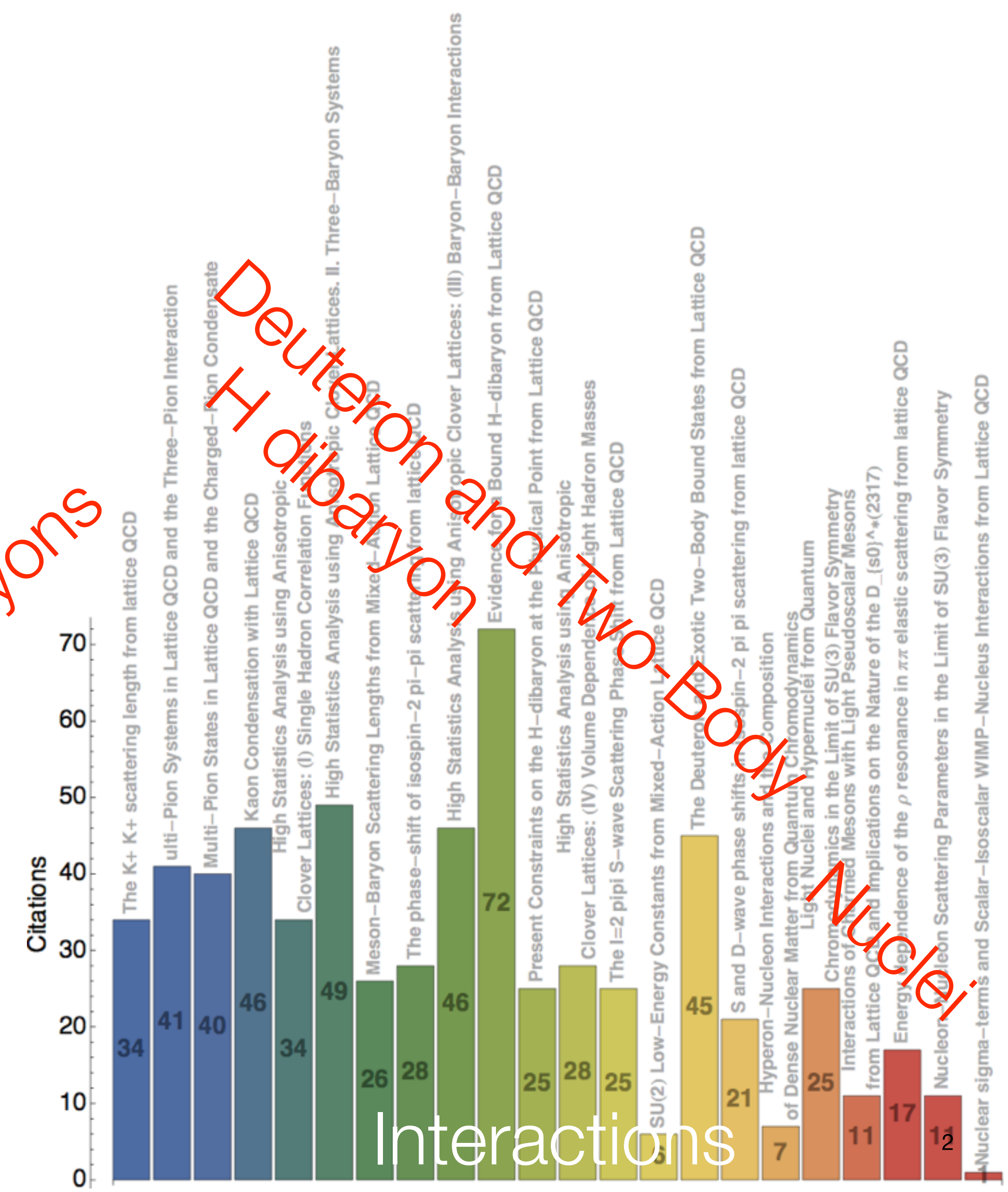
(Spires Citations)











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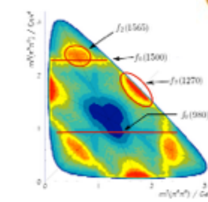
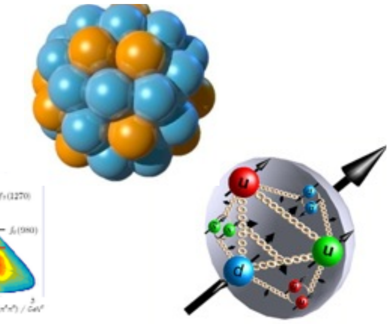




Spectroscopy : 992 cites

Interactions : 638 cites

Structure : 622 cites

3

3) What were the responses to last year's review's suggestions?

2013 suggestion #2: The review panel encouraged USQCD to make its allocation policies as transparent as possible, and to share negative reviews and comments and discuss the issues involved with the relevant PIs.

For the last two years, the SPC has been making an effort to make their decision-making more transparent by making their reviews more detailed and fuller and by increasing the discussion of the allocation procedures and results at the all hands meetings. This year, they have begun including more detailed comments on areas in which the committee had concerns. In one case, the committee felt that the proposed calculation was interesting and the strategy was sound, but the project was planning on using a non-optimal set of ensembles. In another case, the project was interesting, but was too exploratory to merit the size of the requested allocation. In yet another case, the calculation was judged to have been done earlier and better by two other groups. In such cases, the issues were communicated to the PIs, and a response was requested.

The result has been a higher satisfaction with the allocation process in the user survey.

2013 suggestion #4: In answer to a question from the review panel, it was noted that USQCD has produced ~60 Ph.D.'s over the last 10 years. The review panel considered this productivity impressive and suggested that the collaboration compile these statistics annually.
The Collaboration conducted a new and more complete survey of PhDs this year with the following result.

The increase of ten from last year to this year consisted of seven new PhDs, and a few earlier ones that were turned up that we had missed last year.

	2013	2014
Kuti	3	3
Savage	4	5
Sharpe	4	4
Beane	2	2
Kaplan	1	2
MILC	10	11
Columbia	13	15
Karsch	3	4
BU	3	3
MIT	5	6
Maryland	3	3
CMU	3	5
Willam & Mary	3	4
Kentucky	3	3
	60	70

Suggestions 1., The review panel suggested that that USQCD consider implementing a mechanism to promote a regular turnover of its Executive Committee (EC) members through a democratic process which would involve the entire collaboration. Several reviewers encouraged USQCD to elect one or more members of the EC by popular vote at the annual All-hands Meeting.

3., : It is important that the Executive Committee remains responsive to long-term changes in the field and its mission. To feel the pulse of the LQCD community, it may consider adding one or two term-limited members that are elected by the entire collaboration.

5. The current governance method is well-suited to achieving several goals: finding people for the EB and SPC who are well-qualified to lead, who are willing to expend the time and the energy necessary to do it, who have a vision of the field, and who are compatible in temperament and goals with the other members of the leadership team. However, the review panel noted that following present procedures the EC could turn over merely by replicating itself, thereby excluding the possibility that people with radically different, but useful ideas, could join the leadership team. The leadership might not be adequately sensitive to the opinions of the younger members of USQCD. However, in light of the success of USQCD in governing itself and the hardware project, the review panel does not think major changes are required. It does, however, urge USQCD leadership to continue to think about these issues and fine time its governance processes accordingly.

See below.

2013 suggestion #6: The USQCD sponsored workshops have added to the impact and visibility of lattice calculations. It is important to continue and even expand these efforts, if possible. The US experimental program will be evolving rapidly over the next few years and the lattice community must continue to stay abreast of those developments. Participating in the Snowmass process, the upcoming new P5 process and related activities within HEPAP are all important here. Perhaps the lattice community should lobby for an increased role in DOE advisory committees such as HEPAP and NSAC.

(See below)

4) The US seems more productive than other parts of the world. Why is this so given that its funding seems no larger.

The US is more productive in the areas on which it is focused. It is focused much more on the needs of experiment and the particle physcis program than are many (but not all) other efforts. Much important lattice work on field theoretic aspects of lattice field theory has gone on in Europe. Some important HEP phenomenology is taking place in Europe.

The US lattice effort is also much better organized and more coherent than programs abroad. The physics program is discussed and made coherent on a national scale. The US has a well established national software effort which is beginning to be copied in Europe. The US has nationally established policies on sharing gauge configurations.

6) Does USQCD have by-laws? The Project Executive Plan on the review web site has the official description of the role of the USQCD Executive Committee and spokesperson.

5.1.6 LQCD Executive Committee

The charter of the Lattice QCD Executive Committee is to provide leadership in developing the computational infrastructure needed by the United States lattice gauge theory community to study Quantum Chromodynamics (QCD), the theory of the strong interactions of subatomic physics. The Executive Committee is responsible for setting scientific goals, determining the computational infrastructure needed to achieve these goals, developing plans for creating the infrastructure, securing funds to carry out these plans, and overseeing the implementation of all of the above. The Executive Committee advises the CPM regarding scientific priorities and the computing resources needed to accomplish them. The Executive Committee appoints the Scientific Program Committee, which allocates the project's computational resources. The chair of the Executive Committee is also the chair of the LQCD-ext Change Control Board (CCB). In addition, the Executive Committee nominates a second scientist to serve on the CCB. The role of Executive Committee members on the CCB is to represent the interests of the users.

Current members of the Executive Committee are expected to serve for the duration of the project. If a vacancy occurs, it is filled by a vote of the remaining members of the Executive Committee. Appendix B contains a list of the current members of the Executive Committee.

Responsibilities

- Sets the scientific goals and determines the computational infrastructure needed to achieve them
- Establishes procedures for the equitable use of the infrastructure by the national lattice gauge theory community
- Arranges for oversight of progress in meeting the scientific goals
- Arranges regular meetings of the national lattice gauge theory community to describe progress, and to obtain input
- Manages the national lattice gauge theory community's SciDAC grant and provides coordination between the work done under that grant and in the current project
- Appoints the members of the Scientific Program Committee
- Represents the interests of the user community by appointing two members to serve on the CCB.

5.1.7 Spokesperson

The Chair of the Executive Committee serves as the Scientific Spokesperson for the project. Responsibilities

- Determines scientific goals and required computational infrastructure together with the LQCD Executive Committee
- Chairs the LQCD Executive Committee

Interactions

- Principal point of contact to DOE on scientific matters related to the project
- Presents the project's scientific objectives to the DOE, its review committees and its advisory committees
- Liaison between the Executive Committee and the CPM, relating the Executive Committee's priorities to the CPM, and transmitting the CPM's progress reports to the Executive Committee

5) Say more about the management of USQCD. What is the procedure by which rotations are made on the Executive Committee. Is the decision made internally.

Suggestions 1., 3., 5. The current governance method is well-suited to achieving several goals: finding people for the EB and SPC who are well-qualified to lead, who are willing to expend the time and the energy necessary to do it, who have a vision of the field, and who are compatible in temperament and goals with the other members of the leadership team. However, the review panel noted that following present procedures the EC could turn over merely by replicating itself, thereby excluding the possibility that people with radically different, but useful ideas, could join the leadership team. The leadership might not be adequately sensitive to the opinions of the younger members of USQCD. However, in light of the success of USQCD in governing itself and the hardware project, the review panel does not think major changes are required. It does, however, urge USQCD leadership to continue to think about these issues and fine time its governance processes accordingly.

We have considered both making the rotation process of the Executive Committee more regular and possible role of elections in Executive Committee rotations. The Executive Committee has been constituted so that it represents a balance between high-energy physics and nuclear physics, between the main areas of physics interest, and between the most important of the constituent physics collaborations. Rotations on the committee have been made to carefully maintain the desired balance.

Our recent policy has been to rotate at the rate of about one rotation per year with a view toward making a rotation of most of the committee over a period of about ten years, while maintaining the balance just described. This year, we have decided to make the terms of Executive Committee members more regular and predictable by reconsidering the membership of all committee members at the rate of two per year starting with the most senior. We have defined seniority by years served on the committee, and by years from PhD in the case of ties. We expect to continue to make approximately one rotation per year, as we have done for the last few years.

This procedure brought to consideration this year two of the most senior members of the Executive Committee, Bob Sugar of the MILC Collaboration and Norman Christ of the Riken-Brookhaven-Columbia Collaboration (RBC). The Executive Committee consulted with members of MILC and RBC, and these collaborations consulted among themselves on their representation on the committee. The result was that the Executive Committee has asked Norman Christ to continue on the committee and that Carleton DeTar of MILC and the University of Utah has been asked to replace Bob Sugar on the Committee. DeTar is in the middle of a term as chair of the University of Utah physics department and asked that the beginning of his service on the committee be deferred until his term as chair finishes in 2016. The EC has accepted that request.

Some of the members of the Executive Committee are distinguished physicists who do not represent large collaborations. The Executive Committee is considering other ways of making these rotations including elections at the All Hands Meeting.

7) Is there a succession plan for collaboration leadership positions?

The rotation procedure outlined above is the succession plan.

8) Do you expect leadership-class resources to decline over the next few years. How will this affect your program. What will be the role of large NSF resources like Blue Waters?

9) How does the SPC decide on allocations to each sub-field?
From SPC:

How does SPC come up with total allocations of time for each of the 4 sub-areas?

- Rough guide is 50-50 split in allocations, but ultimately, projects are allocated based on merit and need
- Within each 50%, no official division - in fact, relative divisions have changed

- From beginning, USQCD has supported BNL, FNAL, Jlab (HEP+NP)
- Facilities do have influence in choosing types of resources to support their programs
- Vital to support strong USQCD programs leading DOE expts
  - Projects need computational resources; otherwise, they wither and die
  - Thus, significant concern about how decrease of funding will impact USQCD programs

How do over-subscriptions impact allocations?

- The white-papers (& science talks yesterday) outline computational requirements to achieve long term physics objects
  - Far exceed available resources today
- Proposals to SPC must at least reasonably fit in available resource envelope - otherwise, unrealistic
  - Projects thus are trying to complete some limited objective
  - Question then is how does SPC decide on full allocation if over-subscribed – next slide
- However, over-subscriptions do strongly suggest what individual projects view as practical methods (platforms) to use
  - Strong demand suggests to facilities what are desired platforms (GPUs? Clusters? BGs?, Phi-s?) – buy/invest in more

2014 requests

- 490M native (800M Jpsi) BG/Q (regular+zero-priority) - 6 proposals (1.5x)
- 100M native (100M Jpsi) XK7 ORNL - 3 proposals (1.6x)
- 400M Jpsi clusters - 20 proposals (1.4x)
- 8M gpu-hours native (656M Jpsi) GPUs - 6 proposals (1.5x)
- 71M native (130M Jpsi) BNL/BGQ - 4 proposals (1.5x)
- Projects cannot be moved back and forth to load balance – constrained system

What criterion is used to decide full funding for proposals

- Proposals are classified according to the criterion they are to be evaluated: Type A or B.
- Type A: address critical needs of USQCD
  - Large requests we would expect from only long term, mature, well established projects. New projects requesting large amounts of time will receive very significant scrutiny and probably will not receive a large allocation
  - Large proposals are scrutinized significantly to ascertain whether they do address/achieve the goals of USQCD. Does the project have an established track record? Is the project sufficiently prepared to start the new set of calculations? Are publications coming out? What has been the scientific impact?
  - Ultimately, only a fixed amount of time is available. Long term projects requiring more than the available time will not fair well
- Type B: development
  - Upper bound to time (2.5M): threshold much lower. If a reasonable case is made, then full funding is very likely
  - Projects seeking a renewal are scrutinized to determine if progress is being made along with the potential for growth to type A

What feedback is given to PI-s after allocation

- Resources almost invariably over-subscribed
- This is the type of response for strong proposals:
    - *The study of light pseudoscalar physics, especially the K -> pi pi decay, is important to the goals of the USQCD collaboration. Also, the SPC recognizes that this work, including the scale setting from the Omega mass and the quark mass tunings, is an essential part of your collaboration's physics program. However, the total resources needed by all of the important projects was considerably larger than the available resources, and we therefore cannot grant all of your request. The allocation listed above is the amount available for your project while balancing the needs of the entire collaboration.*
- Based upon complaints received by the SPC that not enough feedback was given to PI-s, the SPC now writes more extensive reports to the PI-s.
- Encouragement for future calculations were suggested: i.e.,
    - *As noted in our earlier comments, the SPC is very interested in seeing the Delta-I = 1/2 K -> pi pi calculation move forward, although that is not part of the work proposed here.*
  - The SPC received a proposal for this work the next year
- We emphasize that significant critical (but constructive) criticism was given to several proposals (but not displayed here)

10) Are experimenters aware enough of lattice results. What are you doing to promote awareness.

There has been a sea change in the awareness of experimenters of lattice gauge theory results over the last five years. We are being invited to address more meetigns of experimenters than ever before, such as g-2, Belle, and BES collaboration meetings. We have already mentioned the regular meetings with experimenters organized by USQCD:

- SLAC, Sept. 16, 2006, Standard Model physics. With BaBar.
- Fermilab, December 10-11, 2007, “Lattice Meets Experiment” in flavor physics.
- Livermore, May 2-3, 2008, “Lattice Gauge Theory for LHC Physics”.
- JLab, Nov. 21-22, 2008, “Revealing the Structure of Hadrons”, Nuclear.
- BNL, June 8-9, 2009, “Critical Point and Onset of Deconfinement”, QCD thermodynamics.
- BU, Nov. 6-7, 2009, “Lattice Gauge Theory for LHC Physics”. BSM.
- Fermilab, April 26-27, 2010, “Lattice Meets Experiment” in flavor physics.
- BU, 8-10 September 2010, “Sixth Workshop on QCD Numerical Analysis, Boston.
- JLab, Feb. 23-25, 2011, “Excited Hadronic States and the Deconfinement Transition”.
- BNL, Oct. 3-5, 2011, "Fluctuations, Correlations and RHIC low energy runs".
- Fermilab, Oct. 14-15, 2011, “Lattice Meets Experiment: Beyond the Standard Model”.
- Boulder, Oct 28, 2012, “Lattice Meets Experiment 2012: Beyond the Standard Model”.
- George Washington University, Aug. 21-23, 2012, “Extreme QCD”.
- BNL, December 5-6, 2013, “Lattice Meets Experiment 2013: Beyond the Standard Model”.
- Fermilab, March 7-8, 2014, “Lattice Meets Experiment, 2014”.

(Suggestion #6 from 2013): The USQCD sponsored workshops have added to the impact and visibility of lattice calculations. It is important to continue and even expand these efforts, if possible. The US experimental program will be evolving rapidly over the next few years and the lattice community must continue to stay abreast of those developments. Participating in the Snowmass process, the upcoming new P5 process and related activities within HEPAP are all important here. Perhaps the lattice community should lobby for an increased role in DOE advisory committees such as HEPAP and NSAC.

We have continued to be active in organizing new workshops with experimenters and theorists, as shown in the slide "Lattice meets experiment meetings" in Paul Mackenzie's talk at the annual review.

In HEP, we were very active in the Snowmass process. Steve Gottlieb served as the co-convener of the Computing Frontier section. Ruth Van de Water and Tom Blum were the Lattice Field Theory sub-conveners for the Computing Frontier, and Don Holmgren was the group's monitor. T. Blum, R. S. Van de Water, D. Holmgren, R. Brower, S. Catterall, N. Christ, A. Kronfeld, J. Kuti, P. Mackenzie, E. T. Neil, S. R. Sharpe, and R. Sugar wrote the Lattice Field Theory report. Steve Sharpe, Norman Christ, and Van de Water were co-conveners of the LQCD task force in the quark-flavor WG. Van de Water, Jack Laiho, and Paul Mackenzie presented talks at the Summer Study.

Paul Mackenzie gave a presentation on the USQCD program to HEPAP at the Sept. 6, 2013 meeting, a meeting at which Steve Ritz of P5 was also in attendance.

Andreas Kronfeld was one of the two main editors (with Bob Tschirhart) of Fermilab's Project X Book. Thomas Blum, Ruth S. Van de Water, Michael Buchoff, Norman H. Christ, Andreas S. Kronfeld, and David G. Richards wrote the Lattice QCD chapter.

There will be a town meeting on computational nuclear physics on July 14-15, 2014, at which David Richards, Martin Savage, and Frithjof Karsch will play leading roles. At the triennial NP-ASCR meeting 29/30 April 2014, Sergei Syritsyn presented topics in cold lattice nuclear physics which are expected to play increasingly important future roles in computational NP.

Recognition of LQCD for Nuclear Physics

Report to the
Nuclear Science Advisory Committee
Implementing the 2007 Long Range Plan
January 31, 2013

"A key part of the 12-GeV physics program at Jefferson Lab is the ability to produce these exotic hybrid mesons using photon beams, which is expected to generate unprecedented numbers of these particles. The GlueX experiment in the new Hall-D is poised to carry out this program using a detector designed to tackle just this problem. *The GlueX experimental program is coupled with both detailed lattice QCD predictions and the strong support of the Jefferson Lab theory center in analyzing and interpreting the expected new data. This puts the U.S. in a unique position to explore this important new science made possible by the 12 GeV CEBAF Upgrade.... "*

National Academy of Sciences report: *Nuclear Physics: Exploring the Heart of Matter* **2013**

"NUCLEAR PHYSICS AND EXASCALE COMPUTING"

Enormous advances in computing power are taking place, and computers at the exascale are expected in the near future. This new capability is a game-changing event… …and will enable breakthroughs in key areas of nuclear physics. These include providing new understandings of, and predictive capabilities for, nuclear forces, nuclear structure and reaction dynamics, hadronic structure, phase transitions, matter under extreme conditions,….. It is essential for the future health of nuclear physics that there be a clear strategy for advancing computing capabilities in nuclear physics.

RECOMMENDATION: *A plan should be developed within the theoretical community and enabled by the appropriate sponsors that permits forefront computing resources to be deployed for nuclear science researchers and establishes the infrastructure and collaborations needed to take advantage of exascale capabilities as they become available.*

E.g. Impact on NP - Spectroscopy

PR12-13-003 arxiv:1210.4508 & approved JLab proposal - second phase of GlueX project

An initial study of mesons and baryons containing strange quarks with GlueX
(A proposal to the 40th Jefferson Lab Program Advisory Committee)

A. AlekSejevs,[1] S. Barkanova,[1] M. Dugger,[2] B. Ritchie,[2] I. Senderovich,[2] E. Anassontzis,[3] P. Ioannou,[3] C. Kourkoumeli,[3] G. Voulgaris,[3] N. Jarvis,[4] W. Levine,[4] P. Mattione,[4] W. McGinley,[4] C. A. Meyer,[4,*]

⋮

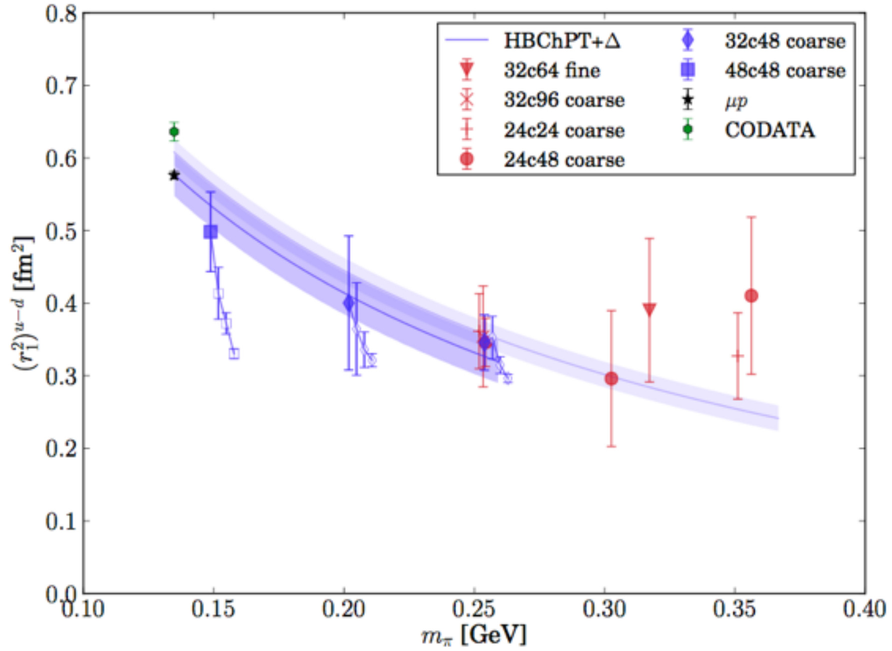
The primary motivation of the GlueX experiment is to search for and ultimately study the pattern of gluonic excitations in the meson spectrum produced in γp collisions. Recent lattice QCD calculations predict a rich spectrum of hybrid mesons that have both exotic and non-exotic J^{PC}, corresponding to $q\bar{q}$ states ($q = u$, d, or s) coupled with a gluonic field. A thorough study of the

arxiv:1212.4891 - science case for JLab Hall B expt.

Studies of Nucleon Resonance Structure in Exclusive Meson Electroproduction

I. G. Aznauryan,[1,2] A. Bashir,[3] V. M. Braun,[4] S. J. Brodsky,[5,6] V. D. Burkert,[2] L. Chang,[7,8] Ch. Chen,[7,9,10] B. El-Bennich,[11,12] I. C. Cloët,[7,13] P. L. Cole,[14] R. G. Edwards,[2] G. V. Fedotov,[15,16] M. M. Giannini,[17,18] R. W. Gothe,[15] F. Gross,[2,19] Huey-Wen Lin,[20] P. Kroll,[21,4] T.-S. H. Lee,[7] W. Melnitchouk,[2] V. I. Mokeev,[2,16] M. T. Peña,[22,23] G. Ramalho,[22] C. D. Roberts,[7,10] E. Santopinto,[18] G. F. de Teramond,[24] K. Tsushima,[13,25] and D. J. Wilson[7,26]

E.g. Impact on NP - Structure

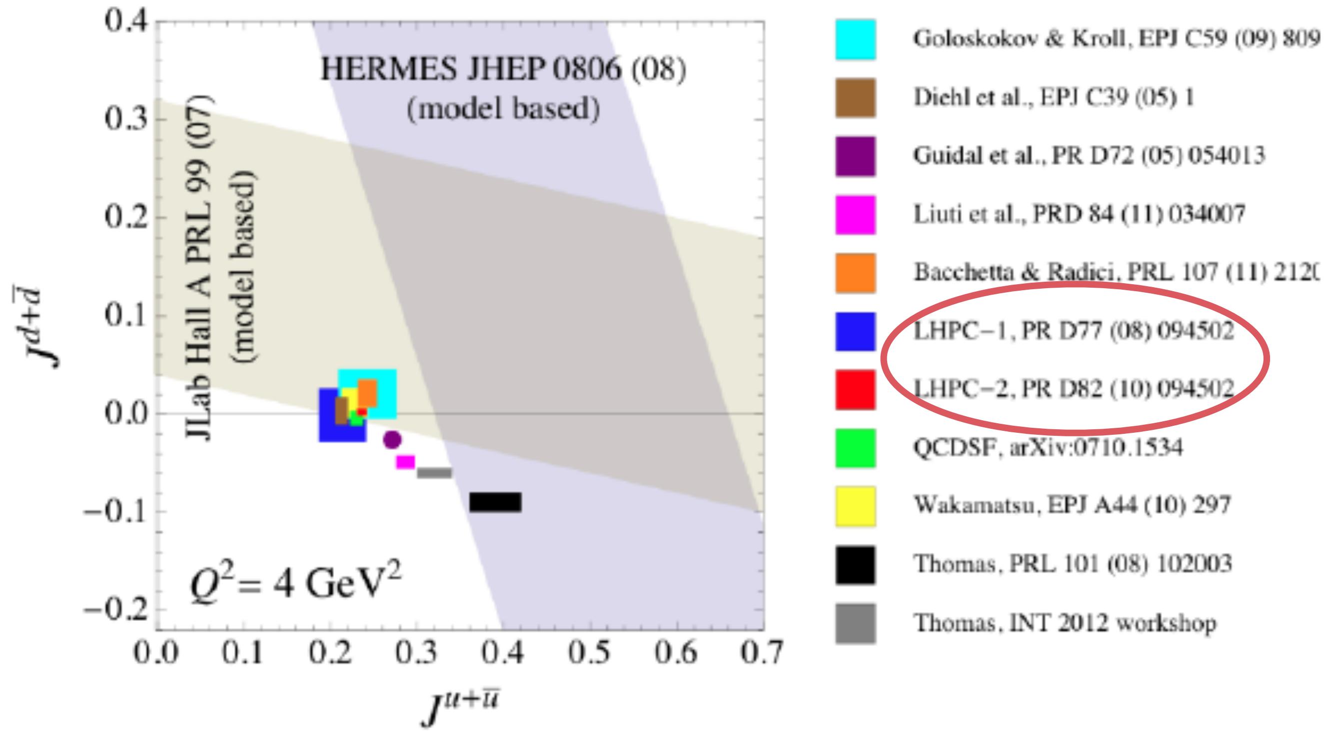


Lattice calculations of precision to resolve muonic and electronic proton charge radius

Understanding origin of spin

Physics Opportunities with the 12 GeV Upgrad[e at] Jefferson Lab

Jozef Dudek, Rolf Ent, Rouven Essig, Krishna Kumar, Curtis Meyer, Robert [...] Eddine Meziani, Gerald A. Miller, Michael Pennington, David Richards, Larr[y] Young



E.g. Impact on NP - Nuclei

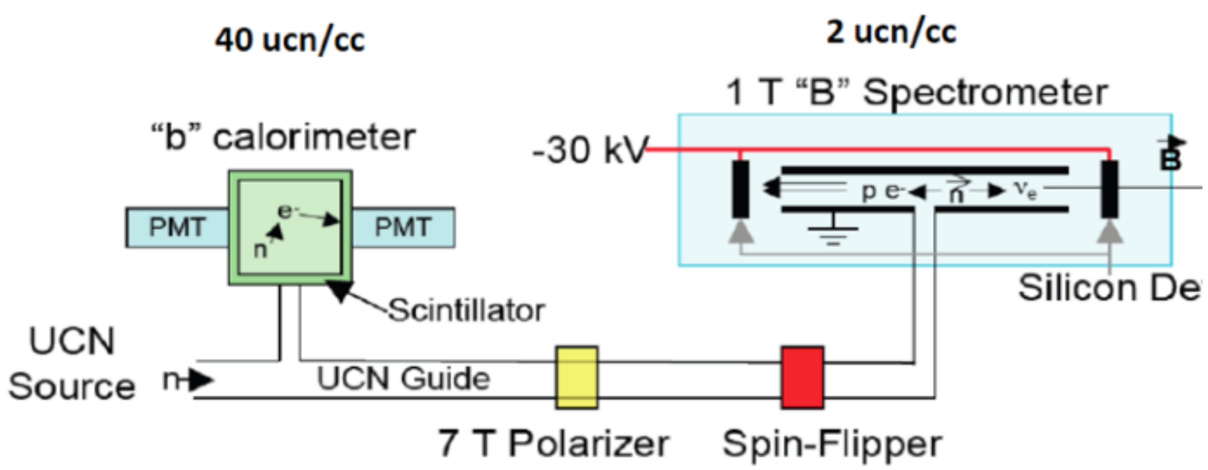
Search for evidence of ${}^{3}_{\Lambda}n$ by observing $d+\pi^-$ and $t+\pi^-$ final states in the reaction of ${}^{6}Li+{}^{12}C$ at 2 A GeV

C. Rappold,[1,2,*] E. Kim,[1,3] T.R. Saito,[1,4,5,†] O. Bertini,[1,4] S. Bianchin,[1] V. Bozkurt,[1,6] M. Kavatsyuk,[7] Y. Ma,[1,4] F. Maas,[1,4,5] S. Minami,[1] D. Nakajima,[1,8] B. Özel-Tashenov,[1] K. Yoshida,[1,5,9] P. Achenbach,[4] S. Ajimura,[10] T. Aumann,[11,1] C. Ayerbe Gayoso,[4] H. C. Bhang,[3] C. Caesar,[11,1] S. Erturk,[6] T. Fukuda,[12] B. Göküzüm,[1,6] E. Guliev,[7] J. Hoffmann,[1] G. Ickert,[1] Z.S. Ketenci,[6] D. Khaneft,[1,4] M. Kim,[3] S. Kim,[3] K. Koch,[1] N. Kurz,[1] A. Le Fèvre,[1,13] Y. Mizoi,[12] L. Nungesser,[4] W. Ott,[1] J. Pochodzalla,[4] A. Sakaguchi,[9] C.J. Schmidt,[1] M. Sekimoto,[14] H. Simon,[1] T. Takahashi,[14] G.J. Tambave,[7] H. Tamura,[15] W. Trautmann,[1] S. Voltz,[1] and C.J. Yoon[3]
(HypHI collaboration)

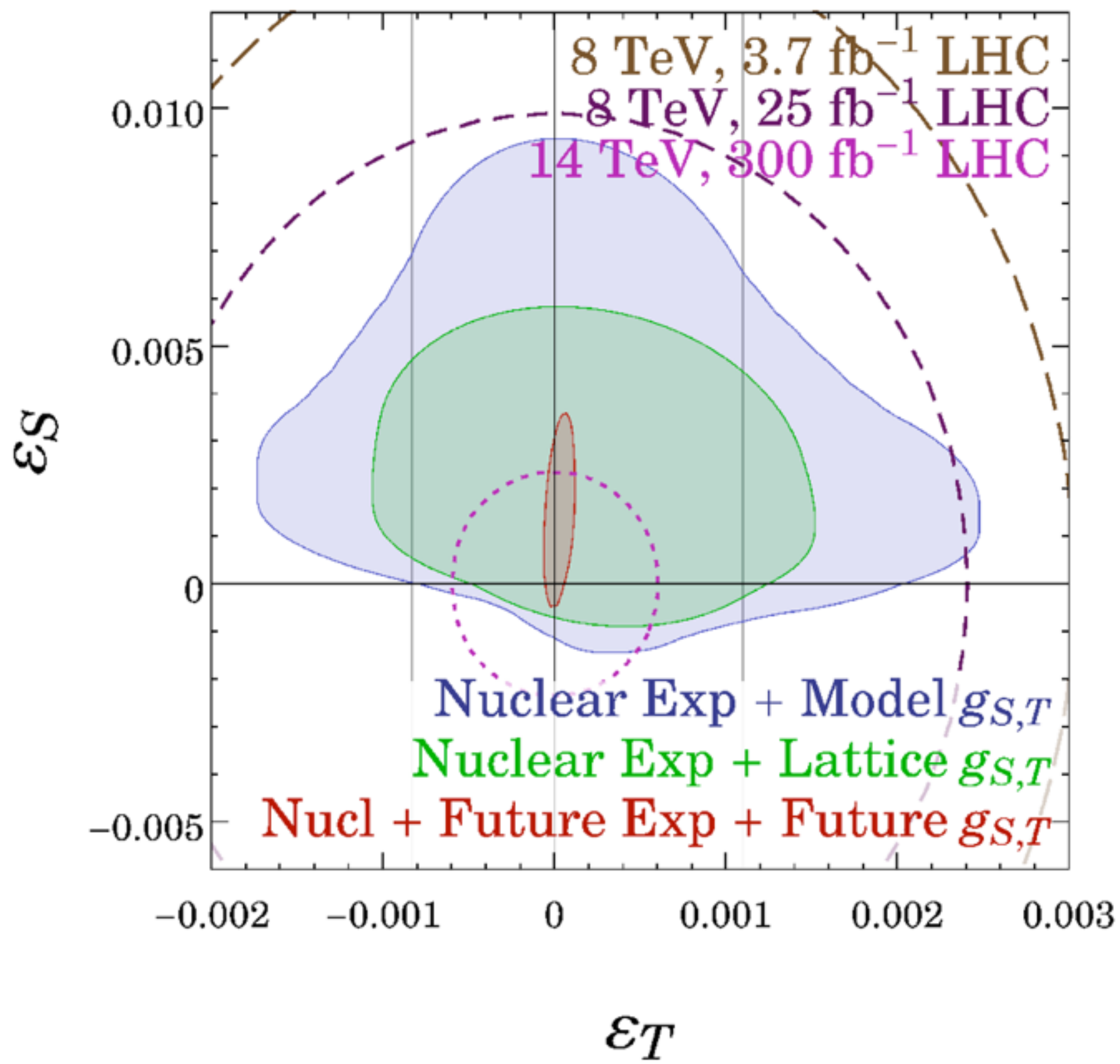
background induced by the Λ-hyperon. Garcilazo et al. studied theoretically the nnΛ state and it revealed that it should be unbound [24], however recent lattice QCD calculations for three-body states [25] indicate that ${}^{3}_{\Lambda}n$ might be bound. Additional considerations from R.H.

NPLQCD Collab

E.g. Impact on NP - Fundamental Symmetries



LANL Ultra-cold Neutron experiment



Bhattacharya et al, Phys.Rev. D89 (2014) 9, Phys.Rev. D85 (2012) 054512

In thermodynamics.

interaction with the experimental community:
– close contact with experimental groups (STAR, PHENIX, ALICE)
– talks at experimental collaboration meetings
– joint publications (FK and P. Braun-Munzinger)
– joint organization of workshops and conferences
– input to the experimental program (Beam Energy Scan); 'design' of observables;